

College Bound in Middle School & High School?

*How Math Course
Sequences Matter*

The Center for the Future of Teaching and Learning at WestEd is dedicated to improving teacher development policy and practice. For more than a decade, the Center has been steadfast in the pursuit of its mission to ensure that every student in California's elementary and secondary schools has a well prepared, effective, and caring teacher. WestEd, a research, development, and service agency, works with education and other communities to promote excellence, achieve equity, and improve learning for children, youth, and adults.

College Bound in Middle School & High School? How Math Course Sequences Matter originated from the Strengthening Science and Math Education in California initiative begun in 2010 initially to examine the status of science teaching and learning in California. and then expanded to include math as well.

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Executive Summary.....

As California competes for jobs in an increasingly competitive global economy, the state faces a looming shortage of highly educated workers (PPIC, 2012). For a variety of reasons, the need for individuals with degrees in science, technology, engineering, and mathematics (STEM) is of particular concern. If we want California students to be able to successfully pursue higher education, especially in STEM, keeping them on track throughout their middle- and high-school academic experience is essential. Nowhere is this more true than in the discipline of mathematics where understanding develops cumulatively, requiring that students master progressively more complex building-block concepts and skills in order to be successful in each next-higher-level course.

Prior research confirms that success in high-level mathematics in high school is predictive of postsecondary success and careers in STEM fields (Adelman, 1999). Similarly, we know there to be a close connection between students' relative success in their middle-school academic experiences and their subsequent performance in high school (see, for example, Oakes, Gamoran, & Page, 1992; Wang & Goldschmidt, 2003; and Stevenson, Schiller, & Schneider, 1994).

This study, funded by the S.D. Bechtel, Jr. Foundation and the Noyce Foundation, digs deeper into this middle- and high-school connection as it applies to STEM, in order to better understand the degree to which California students stay on the trajectory for STEM-related attendance eligibility at California's public universities and, if students veer off the trajectory, to better understand when and why. Thus, researchers examined math and science course-taking patterns for a representative cohort

of some 24,000 California students who were enrolled in grade 7 in 2004/05 and stayed in their district through grade 12 in 2009/10. For their analysis, researchers used a comprehensive set of transcript data from 24 unified (i.e., K–12) districts. In examining a student's course patterns, researchers also looked at the student's performance in each course, as demonstrated by the grade earned, and student proficiency, using as a proxy the student's score (e.g., Below Basic, Basic, Proficient) on the related California Standards Test (CST) for each course (e.g., the algebra 1 CST).

In addition, researchers sought to understand whether districts would find this kind of course-taking analysis helpful in their own efforts to keep students on the trajectory to university eligibility and success. To that end, after analyzing data in the statewide student sample, researchers conducted a separate analysis of the data for 3 of the 24 districts in the state sample, then had in-depth conversations with district representatives about how useful they found the analysis to be and how they might use it.

Although the study looked at students' science course-taking, this report focuses more tightly on the mathematics-related findings, partly because it turns out that course-taking patterns and performance in science are quite similar to, though less complex than, those in mathematics and partly because mathematical understanding, while not sufficient, is essential to student success in some key high school science courses, such as chemistry and physics. The math findings follow.

Finding 1: Math performance in grade 7 is predictive of high-school math course-taking.

Students who perform well in grade-7 math are likely to take more-advanced courses in high school compared to those who struggle with middle-school math. Yet grade-7 performance does not absolutely predict subsequent course enrollment. For instance, in grade-7 math, 23 percent of students who earned better than a B average took algebra 1 in grade 9, while some students who earned lower than a D average took the more advanced course of geometry in grade 9.

Finding 2: While the majority of students who achieved at least Proficient on their math CSTs are those who took algebra 1 in grade 8, geometry in grade 9, and algebra 2 in grade 10, in general this accelerated pathway does not support students who are not proficient in math in grade 7.

Using algebra 1 as an example, 34 percent of those in the study sample had achieved at least Proficient on the algebra 1 CST by the end of grade 11, but 25 percent had done so by the end of grade 8. In other words, almost three quarters of the students who ever attained proficiency or higher on the algebra 1 CST were on an accelerated math track in middle school. Similarly, 69 percent of the students who were ever able to achieve proficiency or higher on the algebra 2 CST were on an accelerated math track, having taken algebra 2 in grade 10. Students who had not scored at the proficient or higher level on the grade-7 CST had far-more-complex course sequences than their higher-scoring peers and, by the end of high school, many of them had never reached proficiency on the algebra 1 or algebra 2 CSTs. Sub-group analysis indicates clear differences between groups of students from varying

socio-economic backgrounds. Students in our analysis who qualified for free- or reduced-price lunches showed lower proficiency rates on all math CSTs.

Finding 3: Many students repeat algebra, but few repeaters achieve proficiency on their second attempt.

Roughly one third of students in the study sample repeated algebra 1 at some point between grades 7 and 12 — repetition that yielded discouraging results: Only a small percentage of students who repeated algebra 1 attained proficiency on the algebra 1 CST the second time they took the course. Among those who took the course in both grade 8 and grade 9, the grade-9 algebra 1 CST proficiency rate was 21 percent. Among those who took the course in both grade 9 and grade 10, the grade-10 algebra 1 CST proficiency rate was just 9 percent. These low proficiency rates illustrate that algebra 1 repeaters are often unsuccessful at demonstrating content mastery their second time around.

Finding 4: Districts are keenly aware of poor student performance in mathematics but less aware of course-taking patterns.

Staff in each of three districts interviewed for the study were already keenly aware of how their students had been performing in math, so our analytic results did not surprise them. In fact, each of the three districts had already undertaken efforts to boost math outcomes.

Finding 5: Districts feel great urgency to improve algebra outcomes.

Interviewees from each of the three districts described experiencing great pressure to improve mathematics achievement and described district efforts to address shortcomings. It was clear that their efforts emerged

from a particular concern about student performance in algebra. District efforts to address this issue include

1. Improving course-placement criteria so as to assign middle- and high-school students to appropriate math courses based on their current math knowledge;
2. Developing middle- and high-school courses designed to meet the needs of students who are not ready for the math-related A-G courses;
3. Providing teacher professional development that focuses on strategies for teaching key algebraic concepts.



One challenge of reporting student outcomes from a large analytic dataset alone is that, oftentimes, researchers know very little about the education inputs underlying the data. By contrast, educators and decision-makers in individual districts should have a good grasp of the content, instruction, and elementary mathematics preparation that help to explain the data on student transcripts. Thus, an individual district's replication of the type of analysis employed in this report promises to yield actionable information. Should districts choose to conduct such analysis, we suggest the following specific areas for consideration and possible action.

Math matters in elementary school.

While this research focuses exclusively on middle- and high-school math course-taking, the large variation in students' grade-7 math performance suggests that more work must be done at the elementary level to prepare students for success in middle-grade math.

When students take algebra 1 (that is, in which grade) is less important than whether students are ready to take it.

The decision about when a student should take algebra 1 (e.g., grade 8? grade 9?) should be based on a careful review of the student's record to date in mastering pre-algebraic concepts, measured in several ways, including prior-year CST scores, teacher recommendations, results from district-administered benchmark assessments, and consultation with parents and counselors.

Having students repeat algebra 1 is generally not an effective strategy for supporting students who struggle in their first attempt at algebra.

If repeating a course doesn't help most students, what is the alternative for those who lack the foundational skills necessary for the next-higher level of math? In considering this question, it may help to distinguish between having a student *repeat* a course (with the exact same content and the same instructional strategies, if not the same teacher) and having a student *re-take the same general content but have it taught in a different way*. This latter approach calls for a careful review of district and school-level instructional support strategies in algebra, coupled with an examination of individual students' particular learning needs, using diagnostic and benchmark assessments and teacher recommendations — all with the aim of providing more targeted instructional approaches and supports as students revisit the foundational algebraic concepts and skills that have heretofore confounded them.

Irrespective of students' math performance, taking four years of high-school math strengthens their postsecondary opportunities.

For students seeking entrance to one of California's public university systems, a fourth year of math is strongly recommended. Yet our analysis shows that slightly more

than 30 percent of students in the study sample did not take math during their senior year. For those who don't study math their senior year (as well as for others who may not move directly from high school to college), having to take a college placement test after at least a year away from math can be a major deterrent to placing into a college-level math course; and students who do not do well on their placement test are likely to end up in a developmental, or remediation, math course, which yields no college credit.

Current course sequences are typically not cost effective.

The common pattern of students repeating courses without succeeding has direct implications for how resources are being used, and how they might be allocated differently. School districts should review the design of courses and course sequences with cost considerations in mind — costs related to time, teacher allocation, and student placement — to assess whether their systems are operating as cost effectively as possible.

At the state policy level, the following additional considerations are warranted.

State-level policy incentives that encourage districts to have students complete algebra 1 in grade 8 should be revisited.

California State Board of Education policy currently encourages districts to have students complete algebra 1 before starting high school; this is incentivized through a

penalty schools receive for having grade-8 students who take the general math CST rather than the algebra 1 CST in grade 8. This policy should be reviewed.

The Common Core State Standards can enable substantial revisions in instructional approaches in math.

Implementation of the Common Core State Standards (CCSS), with their emphasis on deeper learning in math, provides a new opening for discussions of math instruction, course pacing, and course placement. State policy can reinforce district initiatives that support professional development for teachers, provide for updated instructional materials, and support innovations in instructional methods.

Strengthening the supply of qualified math teachers in California is essential.

When it comes to learning math, the quality of instruction matters. With significant numbers of California students ill equipped to move forward in math, guaranteeing strong instruction from elementary school through high school is paramount. How the state supports the pipeline for math teachers — preparing them, recruiting and supporting new teachers, and continuing to support and develop veteran teachers in their work — is critical.

Acknowledgments

In 2011, the Center for the Future of Teaching and Learning at WestEd examined and reported on the status of elementary and middle school science education in California. As a next step in the Strengthening Science and Math Education in California initiative, we extended the scope of the research to include mathematics and science in middle grades and high school. In this newest report, *College Bound in Middle School and High School? How Math Course Sequences Matter*, we provide new information on course-taking patterns in math and science in California middle and high schools and their implications for students' academic success. Insights gained from the research are intended to inform instruction and education policy in ways that improve student academic outcomes and encourage an increase in student participation in the disciplines of science, technology, engineering, and mathematics. The research was funded by the S.D. Bechtel, Jr. Foundation and the Noyce Foundation.

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Introduction

As California competes for jobs in an increasingly competitive global economy, the state faces a looming shortage of highly educated workers (PPIC, 2012). And, with the state economy heavily fueled by innovation in the science and technology sectors, the need for students with degrees in science, technology, engineering, and mathematics (STEM) is of particular concern. Even employers in other fields are increasingly seeking STEM-educated employees because these employees possess a set of core competencies that are directly transferable across a range of highly paid non-STEM occupations (Carnevale, Smith, & Melton, 2011). Moreover, the perceived value of having a solid foundation in math and science is evident in the minimum eligibility requirements for California's public university systems: Irrespective of whether an applicant intends to pursue STEM studies, to be eligible for acceptance as an incoming freshman, he or she must have taken, and passed with at least a C, two years (with three recommended) of high-school science and three years (with four recommended) of high-school math, including algebra 1, geometry, and algebra 2.

We already know a lot about the value of keeping students on track in their secondary school academic endeavors. An existing body of research confirms what common sense suggests — that there is a close relationship between students' high school academic performance and their subsequent success in higher education and beyond (see "Confirmed Connections: What the Research Says" on page 5). We know, for example, that success in high-level mathematics in high school is predictive of post-secondary success and careers in STEM fields (Adelman, 1999). Similarly, we know there to be a close connection between students' relative success in their middle-school

academic experiences and their subsequent performance in high school (see, for example, Oakes, Gamoran, & Page, 1992; Wang & Goldschmidt, 2003; and Stevenson, Schiller, & Schneider, 1994).

Seeking to dig deeper into this middle- and high-school connection as it applies to STEM — and, thus, to better understand how to keep California students on a trajectory toward eligibility for higher education and, possibly, for postsecondary STEM studies — the S.D. Bechtel, Jr. Foundation and the Noyce Foundation funded this study, which examined students' STEM-related course-taking patterns and performance from grade 7 through high school. While the study itself examined patterns and performance in both mathematics and science, this report focuses more tightly on the mathematics-related findings. This is in part because, as it turns out, students' course-taking patterns and performance in science are quite similar to, though less complex than, those in mathematics. But we highlight math patterns for another reason as well — because we know that mathematical understanding, while not sufficient, is essential to student success in some key high school science courses, such as chemistry and physics. In many cases, passing certain math courses is a prerequisite for higher-level science courses.

Course sequencing is especially important in mathematics. More than in some other disciplines, such as history or English language arts and, to a lesser extent, science, mathematical understanding develops cumulatively, requiring that students master certain building-block concepts and skills in order to successfully learn the next-higher level of concepts and skills. The expected K–12 trajectory for learning ever-more-complex mathematics

New State Math Standards

In 2010, California adopted the Common Core State Standards (CCSS) in English language arts and mathematics, replacing standards that had been adopted in 1997 — those under which the students in our analytic sample studied math. The CCSS math standards were developed, in part, to address the common criticism that mathematics education in the United States is “a mile wide and an inch deep” and inconsistently rigorous from state to state. The new standards “significantly narrow the scope of content and deepen how time and energy is spent in the math classroom ... so students gain strong foundations; carefully connect the learning within and across grades so that students can build new understanding onto foundations built in previous years ... [and] require a balance of solid conceptual understanding, procedural skill and fluency, and application of skills in problem-solving situations” (Cocuzza, 2012).

A central objective of the new standards is to greatly increase mathematics proficiency for students leaving high school, resulting in a greatly decreased need for remediation in postsecondary education. Within the California State University system in 2010, 35 percent of regularly admitted freshmen required remediation in mathematics.¹ In the California Community College system, of the students taking the math placement assessment for the Fall 2010 semester, 85.5 percent scored at a level that would place them into remediation (California Community Colleges Chancellor’s Office, 2012). Remedial sequences are costly (students must pay but earn no credit for remediation, or developmental, courses), time-consuming, and often unsuccessful, frequently resulting in students’ failure to progress toward postsecondary degree completion (Venezia, Bracco, & Nodine, 2010; Complete College America, 2012). As school districts move toward full CCSS implementation, a simultaneous review of the course patterns revealed in this study may provide an important additional lens through which to review the structure and content of mathematics courses, for example, how pre-algebraic content is distributed through the years leading up to middle-grades algebra. This kind of review should result in more students developing strong foundations in math concepts, leading to greater success and opportunity to be eligible for higher education and careers.

¹ Data obtained from the CSU website: http://www.asd.calstate.edu/remediation/10/Rem_Sys_fall2010.htm

and ultimately becoming eligible for college and ready for college-level coursework is embodied in the state math standards (see “New State Math Standards” above). These standards are reflected in districts’ recommended sequences and timing for math courses, which we refer to in this study as recommended *pathways*. A pathway consists of the typical order and timing of courses that cohorts of students follow and that is intended to create

smooth transitions between courses and, more importantly, through increasingly challenging course content. At the middle- and high-school levels, this sequencing is often enforced through the use of pre-requisites, where, for example, algebra 1 is a pre-requisite for algebra 2 and pre-calculus is a pre-requisite for calculus.

In contrast, we define the actual sequence and timing of a student’s courses in a particular discipline as his or

her course-taking pattern. So, for example, a student who, as intended by the district, takes algebra 1 in grade 8 but earns less than a C may be required to retake the course before moving on to the next course on the intended pathway. By repeating algebra 1, the student has begun establishing a different math or science trajectory than intended by the district, and that new trajectory may or may not lead the student to meet state university eligibility requirements and may or may not lead to being successful in college STEM studies.

To identify the degree to which California students in grades 7 through 12 are following district math pathways and to better understand when and why students stumble and veer off track, this study analyzed transcript data, including state test data, for a cohort of 24,279 students in 24 different unified (i.e., K–12) high school districts who had been in grade 7 in school year 2004/05 and who completed grade 12. This cohort was followed for 6 years. The analysis examined the math and science courses these students took and the order in which and when they took the courses (e.g., grade 8? grade 10?). Equally important, it examined how students performed, both in the courses (as indicated by the grades earned) and on related statewide tests intended to assess proficiency.

Taking a close look at student performance was key because performance influences, and in some cases

dictates, if and when a student advances to a higher-level course. A student who performs poorly in a course may be required to repeat it before taking the next-higher-level course. Thus, in California, student performance affects whether the student will be able to meet eligibility requirements for state universities. Because meeting math-related eligibility requirements does not guarantee that, if accepted, a student will be successful in college-level math, researchers used students' math scores on the annual California Standards Test (CST) as a proxy for a student's likelihood of being able to take and succeed in related college-level coursework.

In our analysis of the state sample, we found that some students moved seamlessly from course to course, while others did not. It's the course-taking patterns of these students who do not progress seamlessly that were the primary focus of this study.

In addition, we sought to understand whether districts would find this kind of course-taking analysis to be helpful in their own efforts to keep students on the trajectory to university eligibility and success. To that end, after analyzing data in the statewide student sample, we did a separate analysis of the data for 3 of the 24 districts in the state sample, then had in-depth conversations with district representatives about how useful they found the analysis to be and how they might use it.

Confirmed Connections:

What the Research Says

Prior research has documented the importance of course-taking patterns on student achievement, where student achievement is often defined by receipt of a high-school diploma. For instance, Neild, Stoner-Eby, and Furstenberg (2008) looked at how, in the Philadelphia public school system, course failures in grade 8 predicted students dropping out of high school. They found that students with higher percentages of Ds or Fs in grade 8 had higher odds of dropping out of high school. Using a similar dataset of Philadelphia students, Neild and Balfanz (2006) found that 77 percent of grade-8 students who failed a mathematics or English course eventually dropped out of high school. Kurlaender, Reardon, and Jackson (2008) examined a different population of students but came to similar conclusions. Looking at California students in San Francisco, Fresno, and Long Beach, the researchers found that students' grade-point average in grade 7 and course failures in grade 8 were predictive of students' high school completion. These authors also found that the timing of when students take algebra is a strong predictor of students' high-school graduation chances. In two of these three districts, the researchers found a 30-percentage-point difference in graduation rates between students who had completed algebra 1 successfully by the end of grade 8 and those that had not.

Other studies have tracked students beyond high school and into college. One strand of these studies has examined the relationship between high-school math coursework and math remediation in college. Hoyt and Sorensen (1999, 2001), for example, analyzed the transcripts of students at Utah Valley State College and found that students earning higher grades and taking higher levels of math and English courses in high school were

less likely to need remedial courses in college. Another study conducted by ACT (2007), which examined high-school graduates who took the ACT test, also found that students taking higher-level mathematics courses in high school were less likely to enroll in remedial mathematics courses in college. However, this report found that even among students who completed the core curriculum in high school (i.e., three years of math), 84 percent were found to be unprepared to take a credit-bearing first-year algebra course in college. The author concluded that taking the right kind of math courses in high school mattered just as much as taking the right number of math courses.

A second strand of studies that have followed students into college has examined how high-school coursework correlates with completion of a bachelor's degree. Trusty and Niles (2003) analyzed the National Education Longitudinal Study to assess how completing advanced high-school mathematics courses (i.e., more advanced than geometry) predicted students' chances of obtaining a college degree. They found that finishing algebra 2 more than doubled the odds of receiving a bachelor's degree within 8 years of high school. Similarly, in a widely cited research report, Adelman (1999) examined data from the High School and Beyond dataset and found that among all courses taken, the highest level of math courses completed in high school had the strongest relation to college degree completion.

Given the importance of high-school math coursework, other research studies have extended the analysis to examine how middle-school coursework relates to high-school coursework. Findings show that course-taking patterns

in middle school are highly predictive of course-taking patterns in high school. Oakes, Gamoran, and Page (1992) found that the courses students take in junior high school are “scholastically consequential, as the choice predicts later placement in high-track classes in senior high school” (p. 574). Similarly, Wang and Goldschmidt (2003) concluded that middle-school mathematics achievement is related significantly to high-school mathematics achievement, and that “mathematics preparedness is vitally important when one enters high school — where courses begin to ‘count’ and significantly affect postsecondary opportunities” (p. 15). Paul (2005) concluded that “unless we raise achievement in mathematics by the end of eighth grade, there is little that can currently be done at high schools such as the ones we studied to change the percentage of students prepared for regular and competitive eligibility for college” (p. 264). In a study examining the National Education Longitudinal Study, Stevenson, Schiller, and Schneider (1994) found that the level of math that students take in grade 8 is closely related to what they take in high school. These researchers concluded that “students who are in an accelerated mathematics sequence beginning in eighth grade are likely to maintain that position in high school” (p. 196).

However, many students who finish middle school are not prepared to succeed in a rigorous sequence of college-preparatory mathematics courses in high school (Balfanz, McPartland, & Shaw, 2002). So it’s not surprising that previous research has found that among the high-school grades, grade 9 is a key year for students in terms of future academic success. Choi and Shin (2004), who examined student transcripts from a large, urban school district in California, found that most students fall off track for college eligibility in grade 9. Similarly, Finkelstein and Fong (2008) found that more than 40 percent of students did not meet the California State University requirement of completing two semesters of college-preparatory math in grade 9. They concluded

that students who fall off the college-preparatory track early in high school tend to move further from completing a college-preparatory program as they progress through high school. Neild, Stoner-Eby, and Furstenberg (2008) further concluded that poor academic outcomes in grade 9 contribute substantially to the probability of dropping out of high school, even after controlling for grade-8 academic performance and pre-high-school attitudes and ambitions.

Given the importance of grade 9, and of the middle-school grades that strongly correlate with grade-9 achievement, a key area of research has examined the placement of students into math courses in the middle-school grades. Dauber, Alexander, and Entwisle (1996) analyzed initial middle-school placements in math and English courses among students in Baltimore. The authors found that, even after controlling for students’ academic history and educational expectations, African American students were more likely to be placed in remedial rather than regular grade-6 mathematics courses. Hallinan (2003) arrived at similar conclusions when examining more than 4,000 students representing six schools in a midwestern region. Specifically, Hallinan (2003) found that, irrespective of their standardized achievement test score, students could be placed into any of at least three different ability-based class levels. The author concluded that, “while it is often believed that schools rely primarily on test scores and grades to make ability group placements, these data suggest a heavy influence of nonacademic criteria as well” (p. 114). And in a recently released study, Williams, Haertel, Kirst, et al. (2011) examined California students and found that, while the math preparation of incoming grade-8 students varied widely, many students were simply placed into a full algebra 1 course. And the least-prepared students, when placed in algebra 1, generally did not even score at the “Basic” level on the algebra 1 CST at the end of the year. These authors conclude that the practice of placing all

grade-8 students in algebra 1, regardless of their preparation, sets many students up to fail.

Finally, some studies have followed students through high school and college and into the workforce. These studies have shown that math coursework is predictive of future earnings power. For instance, Rose and Betts (2004) examined the High School and Beyond dataset, which followed a nationally representative sample of high-school students for 10 years after high-school graduation. The authors found that students who took more rigorous high-school math courses tended to earn higher salaries 10 years later, even after taking account of demographic, family, and school characteristics, as well as the student's highest education degree attained, college major, and occupation. Levine and Zimmerman (1995) examined two different nationally representative datasets: the National Longitudinal Survey of Youth and the High School and Beyond dataset. These authors found that additional high-school math coursework increases wages for female college graduates.

As the previously cited studies have shown, coursework, particularly in math, is important for future academic and career success. Improvements in data quality are

now allowing researchers to extend the analysis back before high school and into the middle-school grades. It is because of these advances in data collection that we are able to examine course-taking patterns and outcomes beginning in grade 7.

With this prior research in mind, in this study we set out to analyze student transcripts to understand more precisely how students in the 24 districts that made up our statewide sample progressed in their math courses from grade 7 through grade 12. Would we find relationships between grade-7 math course performance and high-school success similar to those reported in the literature? By also looking at CST results we could identify the proportion of students who are able to achieve levels of proficiency in math as they progress through their math course sequence. Would we find that their proficiency levels mirrored or differed from their course grades? And finally, what about the students who struggle through math? Where do these students fall off the math pathway, and are they, nevertheless, able to be successful in math after initially struggling in the subject? We set out to answer questions such as these with the data file that we obtained. This data file is described in the next section.

Methods for Course-Taking Analysis

The dataset used in this report is from the California Partnership for Achieving Student Success (Cal-PASS). This dataset spanned six school years from 2004/05 through 2009/10 and contained demographic characteristics, course enrollment, and California Standards Test (CST) results for students who were in grade 7 in the 2004/05 school year and stayed in the district for the entire six years.² This dataset, which we refer to hereafter as the “analytic transcript data file,” contained data on 24,279 students in 24 unified (i.e., kindergarten through grade 12) California school districts.

Table 1 provides descriptive statistics for both the analytic sample of grade-7 students and the entire grade-7 student population for the state of California, the latter obtained from the California Department of Education website. The analytic sample largely resembles that of the entire state with respect to eligibility for free- or reduced-price lunch, special education status, and English learner status. With respect to ethnicity, the analytic sample is more heavily weighted toward Asian students and less toward White students.

Using the analytic transcript data file, we set out to examine the course-taking patterns in mathematics from grade 7 through grade 12 as well as the proficiency rates in the various math subjects as measured by the CST.³ This entailed tabulating the various course-taking patterns students experienced through these six grades, the frequency with which students repeated courses, the grades they earned and the rates at which students passed courses (with at least two semesters of a grade of C or better),⁴ and the rates at which students achieved proficiency (or better) on the CST.

2 More detailed information about the dataset is in the appendix.

3 While our analysis focused on the subject of math, we also performed some of the same analyses for science. Specifically, we looked at the course-taking patterns of students in science. However, the focus of this report is on math, with some of the science findings being reported in text boxes.

4 We use the threshold of a C because this is the minimum grade for obtaining credit for A-G courses and being eligible for admission to the University of California and California State University systems.

Table 1. Descriptive statistics of the grade-7 students in the analytic transcript data file and in the state of California as a whole for 2004/05

Student Characteristics	Percentage of grade-7 students in the analytic sample (n = 24,279)	Percentage of grade-7 students statewide in 2004/05 (n = 492,917)
African American	8.86	8.15
American Indian	0.55	0.84
Asian	15.33	8.15
Filipino	1.81	2.56
Hispanic	44.65	46.27
Pacific Islander	0.62	0.63
Unknown/ Multiple	0.25	1.39
White	27.92	32.01
Eligible for Free- or Reduced-price Lunch	50.57	49.90*
Special Education	8.52	10.55
English Learner	20.42	20.75

* Eligibility for free- or reduced-price lunch is not reported by grade level on the California Department of Education website. This figure represents all K–12 students.

Source: Analytic transcript data file for the sample and for the statewide student population, the California Department of Education website.



Key Findings From the Analysis

Three main findings emerged from our analysis. The first, deepening what we already know from the research literature, is that student achievement in middle-school math is highly predictive of math course enrollment in high school: Students who do well in math in middle school are much more likely to take more advanced math courses in high school as compared to students who do poorly in middle-school math. The second finding is that the majority of students who attain proficiency on the math section of California Standards Tests (CST) have taken algebra 1 in grade 8, geometry in grade 9, and algebra 2 in grade 10.⁵ We refer to these students as being on an “accelerated math track” (Useem, 1992; McFarland, 2006).⁶ In other words, students who are not on an accelerated math track rarely attain proficiency on the CST.⁷ Upon closer examination of the students not on the accelerated math track, we found that they commonly repeated math courses. And this leads to the third finding: Students who repeat a mathematics course rarely attain proficiency on the CST.

Finding 1: Math performance in grade 7 is predictive of high-school math course taking.

Figure 1 reports the grade-9 math course enrollment based on students’ course grades in their grade-7 math course. Course grades in grade 7 have been averaged because students generally enroll in the course for multiple terms (semesters, quarters, etc.). Figure 1 should be read as follows, using the first set of bars on the left as an example: of the students whose average grade-7 math grade was between an F and a D, 81 percent enrolled in algebra 1 in grade 9 and 8 percent enrolled in geometry. Overall, figure 1 shows that the proportion of students taking the more advanced course (geometry) in grade 9 is higher among those who performed better in their grade-7 math course.⁸ Similarly, students who performed worse in grade 7 are more likely to take the less advanced course (algebra 1) in grade 9 compared to students who performed better in grade-7 math. This provides clear evidence that course performance as early as grade 7 is a strong predictor of future high-school course enrollment.⁹

⁵ The California Standards Test (CST) is the statewide standardized testing system administered to students in grades 2 through 11. There are five performance levels for reporting test results (in increasing order of proficiency): Far Below Basic, Below Basic, Basic, Proficient, and Advanced. In this report we refer to students who score as either Proficient or Advanced as having achieved proficiency.

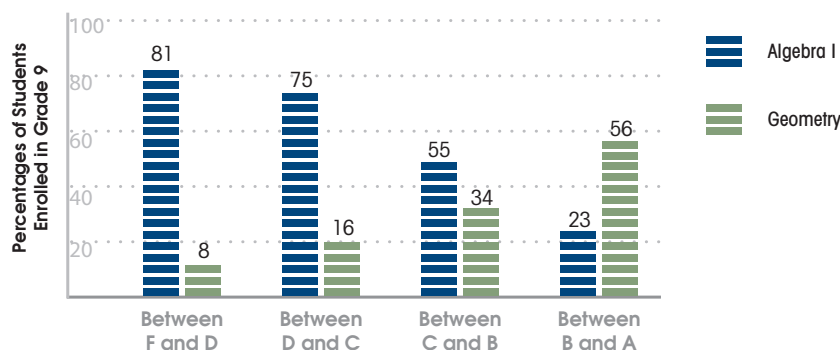
⁶ As described in Useem (1992) and McFarland (2006), the accelerated math track specifically refers to students taking algebra 1 in grade 8, geometry in grade 9, algebra 2 in grade 10, pre-calculus in grade 11, and calculus in grade 12. Note, too, that some students are on an even more accelerated track, taking algebra 2 in grade 9, pre-calculus in grade 10, and calculus in grade 11. In the analytic data file, 5.5 percent of the students took calculus in grade 11.

⁷ As described later in this report, this finding does not suggest that all students should be placed on an accelerated math track; simply doing so would set many students up to fail because they have not achieved a solid math foundation. The goal instead should be to better understand how to deliver a curriculum that would provide these students with a strong foundation in math.

⁸ As discussed later in this report, geometry is considered to be a more advanced course than algebra 1 because algebra 1 is often a prerequisite to enroll in geometry.

⁹ Interestingly, it is not until students achieve at a grade of B or better in their grade-7 math course that they are more likely to enroll in geometry than algebra 1 in grade 9.

Figure 1. Students' grade-7 math performance and subsequent grade-9 math-course enrollment



Note: For each set of grade-7 average course-grade columns (e.g., between F and D), the percentages of students enrolled in algebra 1 and geometry do not add up to 100 because other grade-9 math courses, all with lower enrollments, are not included on the graph. For instance, for average grade-7 math grades between B and A, the following courses are omitted from the graph: basic math (1 percent of students), pre-algebra (1 percent), algebra 2 (16 percent), pre-calculus (2 percent), and no math (1 percent). These courses have been omitted to improve the readability of the graph.

Source: Analytic transcript data file

That being said, however, a strong (or weak) performance in grade 7 does not absolutely predict a student's course enrollment in grade 9. For instance, figure 1 shows that 23 percent of students who performed well in grade-7 math (i.e., earned better than a B average) still took the less advanced math course (i.e., algebra 1) in grade 9; in addition, some students who did poorly in grade-7 math (i.e., earned lower than a D average) still took the more advanced course (geometry) in grade 9.

If we were to include the same type of figure to show the results of our

Course-Taking Patterns in Science

A similar pattern of early course achievement predicting future course enrollment was found for science classes. For instance, when examining biology course enrollment (biology being the most common course that students took in grades 9 and 10), we found that students were more likely to take biology by grade 10 when they had achieved higher science grades in grade 7. Specifically, the rate of biology enrollment by grade 10 was 96 percent for students who had average grade-7 science grades between B and A; in contrast, the rate was only 80 percent for students who had average grade-7 science grades between F and D.¹⁰ In another example, students were more likely to enroll in physics in grade 12 when they had higher grade-7 science grades: 19 percent of the students with average grades between B and A enrolled in physics, compared with only 3 percent of those who had average grades between F and D.

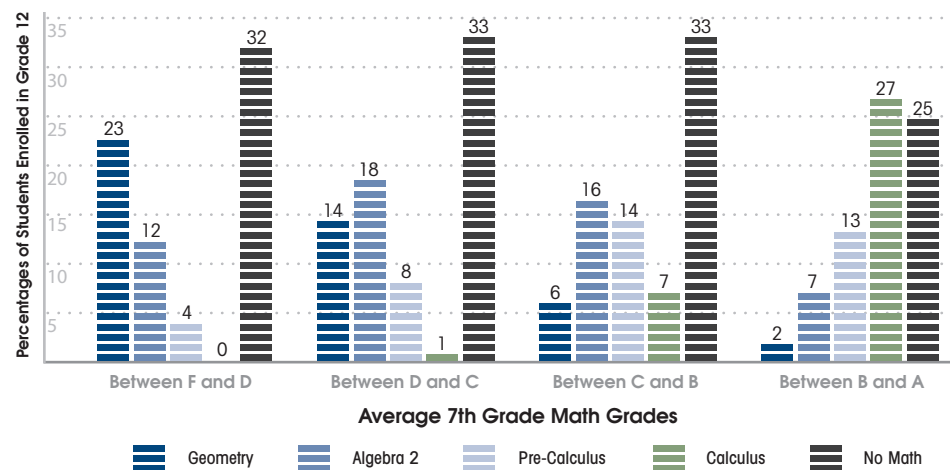
In addition, there is a strong relationship between being successful in math in middle school and being successful in science in high school. For instance, among students who completed algebra 1 by the end of grade 8 (i.e., they passed it in either grade 7 or grade 8 and did not need to take it again), 26 percent went on to pass four science courses in high school (where passing a class is defined as receiving a grade of C or better for two semesters). This percentage was only 5 percent among students who did not complete algebra 1 by the end of grade 8. Conversely, 27 percent of the students who did not complete algebra 1 by then passed no science courses in high school, whereas this was true for only 6 percent among students who completed algebra 1 by grade 8.

¹⁰ As with math grades, we calculated the average science course grade since students often enroll in the course for multiple terms (semesters, quarters, etc.).

course-taking analysis for grades 10 and 11 (plotting average grade-7 math grades on the x-axis and percentages of students enrolled in various classes in either grade 10 or 11 on the y-axis), those figures would tell a similar story to that told in figure 1: Doing well in grade-7 math is highly predictive of enrollment in more advanced courses in high school.¹¹

Figure 2, showing grade-12 math-course enrollment, reveals that students with higher grade-7 math performance are more likely to enroll in calculus in grade 12 as compared to those with lower grade-7 math performance. More specifically, 27 percent of students with grade-7 average math grades above a B enrolled in calculus in grade 12, compared to 0 percent of students who earned below a D in grade-7 math. In addition, as students increasingly earn better grades in grade-7 math (moving from left to right in the figure), they are less likely to enroll in the least-advanced class plotted in the figure (geometry). This figure also shows the high rates at which students take no math course in grade 12: This rate always remains between one quarter and one third, and the lowest rates for those not taking any math in grade 12 are among the students who did best in grade-7 math.

Figure 2. Students' grade-7 math performance and subsequent grade-12 math-course enrollment



Source: Analytic transcript data file

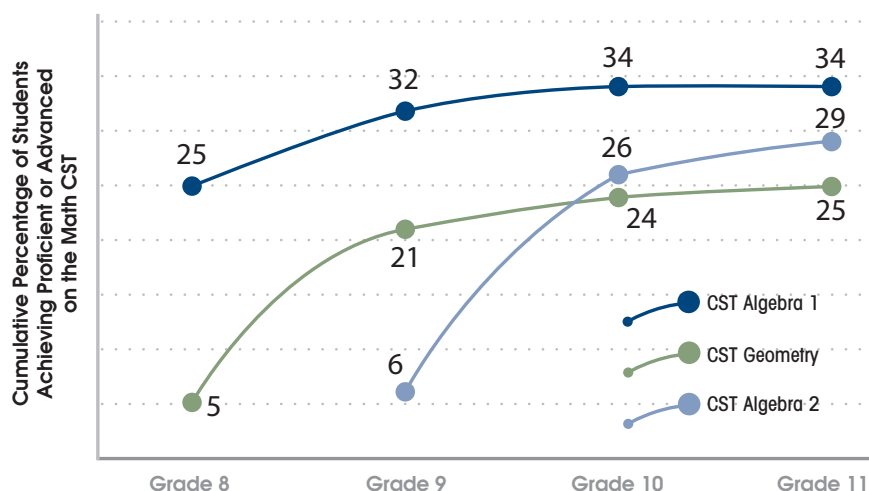
Finding 2: While the majority of students who achieved at least Proficient on the math CST are those who took algebra 1 in grade 8, geometry in grade 9, and algebra 2 in grade 10, in general this accelerated pathway does not support students who are not proficient in math in grade 7.

Figure 3 on the following page presents the cumulative proficiency rates on the algebra 1, geometry, and algebra 2 CSTs for grades 8 through 11 (the CST is not administered in grade 12).¹² Each of the plotted points on each of the three lines were calculated by dividing the number of students who have achieved either Proficient or Advanced

¹¹ These figures are available from the authors upon request.

¹² This analysis focuses on students scoring at least Proficient on the CST (i.e., scoring either Proficient or Advanced on the CST). The rationale for using the Proficient performance level as the criterion for measuring student success is because the educator's goal is generally to get students to attain proficiency. As described by the Educational Testing Service (2012), "The state target is to have all students achieve the proficient and advanced levels by 2014" (p. 257). As defined on the California Department of Education website, reaching the level of Proficient means that students "demonstrate a competent and adequate understanding of the knowledge and skills measured by this assessment, at this grade, in this content area." In contrast, the performance level just below Proficient is Basic. The California Department of Education website classifies students achieving at the level of Basic as demonstrating "a partial and rudimentary understanding of the knowledge and skills measured by this assessment, at this grade, in this content area" (California Department of Education, n.d.).

Figure 3. Cumulative percentages of students reaching Proficient or Advanced on the math CST



Note: 1) The percentages in the figure were calculated by dividing the total number of students who had achieved Proficient or Advanced up through each given grade by the total number of students who ever took the test. The denominators for each of the three lines are as follows: 19,242 students took the algebra 1 CST by the end of grade 11, 17,112 students took the geometry CST, and 12,477 students took the algebra 2 CST. 2) In reporting the number of test takers of each test in each grade, some students may be counted in multiple grade levels. For instance, a student may have taken the algebra 1 CST in both grade 8 and grade 9.

Source: Analytic transcript data file

up through that grade by the total number of students who ever took the course. So in each of the three lines, the denominator is the number of students who ever took the respective CST. For instance, with respect to algebra 1, 25 percent of the students who ever took the algebra 1 CST had achieved proficiency by grade 8. By grade 9, 32 percent of the algebra 1 test-takers had achieved proficiency (that is, an additional 7 percent of the algebra 1

CST test takers achieved proficiency in grade 9). By grade 10 the figure reached 34 percent of all test takers, where it remained for grade 11 as well.

Figure 3 shows that the majority of students who achieved at least Proficient on each of the CSTs are those who took algebra 1 in grade 8, geometry in grade 9, and algebra 2 in grade 10.¹³ Students who followed this pathway are considered to be on an “accelerated math track” (Useem, 1992; McFarland, 2006). This finding is evident by how the lines in figure 3 flatten out in the later grades. In the case of algebra 1, 34 percent of the students achieved at least Proficient on the algebra 1 CST by the end of grade 11, but 25 percent had done so by the end of grade 8. In other words, almost three quarters of the students who ever attained pro-

ficiency on the algebra 1 CST (25 percent divided by 34 percent) were on the accelerated math track.¹⁴ In the case of geometry, 64 percent of the students who ever attained proficiency on the geometry CST were on the accelerated math track (i.e., they took geometry in grade 9). And 69 percent of the students who were ever able to achieve proficiency on the algebra 2 CST were on the accelerated

¹³ While we could have relied instead on course grades to examine proficiency in math, the CST provides a standardized measure by which to evaluate students in different schools and districts. Research has also verified the predictive nature of the CST. For instance, Willett, Hayward, and Dahlstrom (2008) found that “11th grade math CST scores were better predictors than class grades of both the level of and grade in the first attempted community college math course. The study found a moderately strong correlation between scores for most forms of the math CST and college course levels and grades” (p. 3). Similarly, Lefly, Lovell, and O’Brien (2011) found that students needing remediation in their first year of college in Colorado could have been identified by an examination of their state assessment results as early as grade 6. In addition, simply passing a class does not guarantee that the student mastered the course content. Many students who successfully complete intermediate algebra coursework in high school are still placed in remedial math courses in college (Hoyt & Sorensen, 2001). Similarly, ACT (2007) found that among those completing the core math curriculum in high school (three years of math), only 16 percent were ready for a credit-bearing first-year college algebra course.

¹⁴ The exact percentage is 74.56 percent, which was calculated by dividing 25.27 percent by 33.89 percent.

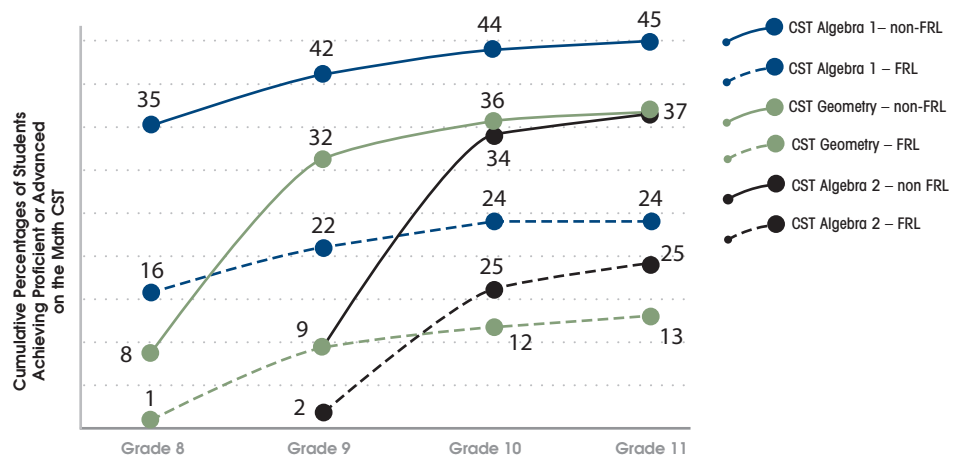
math track (i.e., they took algebra 2 in grade 10).

Figure 4 looks at CST proficiency rates by socioeconomic status, by disaggregating the data based on whether the student qualified for free- or reduced-price lunches (FRL). In each of the three CSTs, students who qualified for free- or reduced-price lunches (“FRL students”) had lower proficiency rates than students who did not qualify (“non-FRL students”). In many instances the proficiency rates among FRL students were about half those of non-FRL students. And in the case of geometry, the proficiency rates among FRL students are one third the rate of non-FRL students. But for both groups, FRL students and non-FRL students, the trajectories of the lines tend to be flat, which is similar to the combined findings in figure 3.

Figures 3 and 4 show that the majority of students who attained proficiency were on an accelerated math track. But what does the math pattern look like for students who do not progress on the accelerated math track? To better understand this, we analyzed students’ math course-taking patterns through high school. To be able to do this and present the results in a systematic way, we assigned a rank to each math course taken by students in the dataset. The ranking scheme goes from 0 (least advanced) to 9 (most advanced). The ranking scheme is as follows: 0 = independent study, 1 = basic math (e.g., grade-7 math, general math, remedial math, basic math, consumer

math), 2 = pre-algebra, 3 = algebra 1, 4 = geometry, 5 = intermediate algebra/algebra 2, 6 = statistics/finite math/discrete math, 7 = pre-calculus/math analysis/trigonometry, 8 = calculus, and 9 = linear algebra.¹⁵ Table 2 reports the 20 most common math course-taking patterns observed in the data. The “course-taking pattern” column presents the course-taking patterns that students took in each of grades 7 through 12. Each digit represents one grade level, with the left-most digit representing grade 7 and the right-most digit representing grade 12.¹⁶ A dash (-) indicates that the student did not take a math course in the specified grade level. The patterns are presented in order of frequency, with the most common listed first. So the most common pattern for students in our sample was basic math in grade 7, algebra 1 in grade 8, geometry in grade 9, algebra 2 in grade 10, pre-calculus in grade 11, and calculus in grade 12.¹⁷ Yet, while this was the most

Figure 4. Cumulative percentages of students reaching Proficient or Advanced on the math CST, disaggregated by free- or reduced-price lunch status



Source: Analytic transcript data file

¹⁵ Our ranking is similar to the ranking scheme used in Willett, Hayward, and Dahlstrom (2008, p. 22) and Burkam and Lee (2003), except that these authors combined algebra 1 and geometry into a single category whereas we separated them because, in California, these courses are usually taken in different grades. Riegle-Crumb (2006) is an example of a study that differentiated algebra 1 and geometry. The classification scheme used by Riegle-Crumb is: 1) remedial or basic math, 2) general or applied math, 3) pre-algebra, 4) algebra 1, 5) geometry, 6) algebra 2, 7) advanced math such as statistics/probability or finite math, 8) pre-calculus, and 9) calculus.

¹⁶ In instances where students take more than one math course in a given grade (such as taking independent study and algebra 2), we report only the highest ranked course.

¹⁷ Note that this is one variant of what we consider to be the accelerated math track. The other variant would be when the student takes pre-algebra in grade 7, algebra 1 in grade 8, geometry in grade 9, algebra 2 in grade 10, pre-calculus in grade 11, and calculus in grade 12. This second variant of the accelerated track is the third most common pattern in table 2 on the following page.

Table 2. The 20 most common math course-taking patterns in the dataset

	Course-taking Pattern ^a	Percentage of Students	Cumulative Percentage of Students
1.	134578	3.30	3.30
2.	134576	2.52	5.82
3.	234578	2.47	8.30
4.	23345-	2.08	10.38
5.	234577	1.68	12.06
6.	13457-	1.65	13.72
7.	234576	1.64	15.35
8.	13345-	1.48	16.84
9.	133457	1.46	18.30
10.	233457	1.44	19.73
11.	345786	1.43	21.17
12.	12345-	1.35	22.52
13.	334578	1.34	23.86
14.	345788	1.28	25.14
15.	23457-	1.27	26.41
16.	233455	1.18	27.59
17.	133455	1.08	28.67
18.	334576	0.92	29.59
19.	22345-	0.87	30.46
20.	12344-	0.78	31.24

a. To more succinctly communicate the patterns in this column, we have assigned a math rank to each of the math courses taken by students in our dataset: 0 = independent study, 1 = basic math (e.g., grade-7 math, general math, remedial math, basic math, consumer math), 2 = pre-algebra, 3 = algebra 1, 4 = geometry, 5 = intermediate algebra/algebra 2, 6 = statistics/finite math/discrete math, 7 = pre-calculus/math analysis/trigonometry, 8 = calculus, and 9 = linear algebra. A dash (-) indicates that students did not take a math course in the given year.

Source: Analytic transcript data file

common pattern, it represents only 3.3 percent of the analytic sample. In fact, the “Cumulative Percentage of Students” column at the far right of the table shows that the 20 most common patterns represent only 31.24 percent of the students in the sample. In all, the study identified approximately 2,000 different math course-taking patterns for students in the sample.¹⁸

A close look at table 2 reveals how common it is for students to take a similar math course in consecutive grade levels. In 12 of the top 20 pathways (numbers 4, 5, 8, 9, 10, 13, 14, and 16–20) students took a course with identical rankings in consecutive grade levels.¹⁹ Because it became apparent that students were often struggling through math in high school, we calculated rates of repeating certain courses among all students in the sample.

Table 3 reports the results of these findings, along with calculations reporting the passing rates of various courses. We have chosen to report in the table a set of repeating and passing relationships that are illustrative of the types of metrics that may be of interest to school district personnel. It is also worth noting that the relationships presented, a subset of the almost limitless list, demonstrate the

¹⁸ While we do not report all the different patterns, information about all of them is available from the authors upon request.

¹⁹ While this often indicates that a student repeated the exact same course, this is not always the case. For instance, the 14th most common sequence (345788) suggests that the student took calculus in both grades 11 and 12. This is the case, but more specifically the student took Calculus AB in grade 11 and Calculus BC in grade 12.

Table 3. Repeating and passing rates among students within the sample

	Percentage
Proportion of the sample who took algebra 1 for the first time in grade 8	56.77
Algebra 1 pass rate in grade 8 among students who first took algebra 1 in grade 8	62.69
Proportion of the sample who took algebra 1 in grades 8 and 9	22.72
Proportion of the sample who took algebra 1 for the first time in grade 9	20.86
Algebra 1 pass rate in grade 9 among students who first took algebra 1 in grade 9	37.60
Proportion of the sample who took algebra 1 in grades 9 and 10	13.49
Proportion of the sample who took algebra 1 in grades 8, 9, and 10	4.43
Proportion of the sample who ever repeated algebra 1	33.57
Proportion of the sample who ever repeated geometry	15.96
Proportion of the sample who ever repeated algebra 2	10.17
Proportion of the sample who ever repeated algebra 1, geometry, or algebra 2	49.70
Proportion who passed algebra 1, geometry, and algebra 2 in grades 8, 9, and 10, respectively	15.28
Algebra 2 pass rate in grade 10 when taking algebra 1 for the first time and passing it in grade 8	70.50
Algebra 2 pass rate in grade 11 when taking algebra 1 for the first time and passing it in grade 9*	40.46
Proportion of the sample who ever passed two semesters of algebra 2*	44.24
Algebra 2 pass rate among students who first took algebra 1 in grade 9*	16.74
Algebra 2 pass rate among students who did not take math in grade 12*	32.06
Proportion of the sample who did not take a math course in grade 12	30.18

Notes: 1. In calculating the percentage of students repeating a course (such as ever repeating algebra 1), we include students who take the same course in multiple grades even if they also take a higher-level course in the second year. For instance, if a student takes algebra 1 in grades 9 and 10 but also takes geometry in grade 10, we consider that student to have repeated algebra 1 in grade 10 since the student had already taken the course in a prior year.

2. Passing a course means that the student received a grade of C or better for at least two terms in the class.

* One district in the dataset had missing course grades for students in grades 11 and 12. This district was excluded from the analysis in all results denoted with a “*.” This had a very negligible effect on the reported results.

Source: Analytic transcript data file

possible analyses that can be conducted when transcript data is available for analysis.

Primarily, table 3 shows that many students repeat courses in high school, in many different ways. For instance, almost half the study population (49.7 percent) repeated either algebra 1, geometry, or algebra 2.

The highest rates of repeating were in algebra 1 (33.57 percent), followed by geometry (15.96 percent), and then followed by algebra 2 (10.17 percent). Only 15.28 percent of the sample passed algebra 1, geometry, and algebra 2 in grades 8, 9, and 10, respectively.

Notably, table 3 also reports the percentage of students who ultimately passed at least two semesters of algebra 2; we see this as a proxy for college eligibility that is represented by the mathematics requirement within the California public universities' A-G completion metric. This figure, 44.24 percent, is a higher figure than the percentage of students who scored at least Proficient on the algebra 2 CST (29 percent). The findings for these

two measures are different: Both (grades and test scores) are important measures of students' academic performance, and both should be used in assessing students' academic performance. The difference between the two percentages illustrates that many students pass the course with a grade of C or better but still do not reach proficiency based on the CST. The implications of this difference cannot be fully untangled here, but one possible line of further investigation would be to examine whether students who pass their course, but do not demonstrate proficiency on the CST, require math remediation in their postsecondary studies.

Finally, table 3 highlights the fact that just over 30 percent of students do not take math in their senior year of high school. One notable consequence is that these students — many of whom have not demonstrated proficiency in math — are forgoing an additional year of math instruction that would, presumably, strengthen their math understanding and skills to some degree. For students who go on to higher education but must

Most Common Patterns in Science

In table 4 we list the 20 most common science course-taking patterns among students in our sample. As we did for math courses, here, too, we assigned a rank to each of 10 possible science courses that students took (with ranks identified in the table note). Each sequence should be read from left (grade 7) to right (grade 12).

While there were approximately 2,000 different math course-taking patterns among the students in our sample, there were over 3,000 different science patterns. The list of the top 20 science patterns in table 4 shows how varied these patterns are. For instance, while students commonly took biology before chemistry, after taking the biology/chemistry sequence students would take either physics, earth or environmental science, anatomy and physiology, biology (again), chemistry (again), or no science course at all. This suggests that the science pathway is less defined than the math pathway (assuming the student passes each class, the typical math pathway is algebra 1, then geometry, then algebra 2, then pre-calculus, then calculus; this is evident through the ranking system developed by Riegle-Crumb [2006], among others). As another piece of evidence of how the science pathway is less defined, biology was the only high-school course that appeared in all top-20 science pathways. Chemistry was the next most common high-school course, showing up in 18 of the 20 sequences. The third most common high-school course in the top 20 sequences was earth or environmental science, showing up 6 times.

take placement tests in order to take credit-bearing courses, forgoing this additional year of math means they will not have had recent practice in math when they take the math placement test.

The struggles that many students experience in their math trajectories lead to the study’s third overall finding, which concerns students’ poor performance when they repeat a math course. Because algebra 1 is of such great concern,²⁰ and because, in California, it is a state-imposed graduation requirement, we focus on the repeating of this course in particular.

Finding 3: Many students repeat algebra, but few repeaters achieve proficiency on their second attempt.

As table 3 shows, 33.57 percent of the sample repeated algebra 1 at some point between grades 7 and 12 — repetition that yielded discouraging results: Only a small percentage of students who repeated algebra 1 attained proficiency on the algebra 1 CST the second time they took the course. Among the students who repeated algebra 1 in grade 9 (i.e., those who took the course in both grades 8 and 9), the grade-9 algebra 1 CST proficiency rate was

Table 4. The 20 most common science course-taking patterns in the dataset

	Course-taking Patterns ^a	Percentage of Students	Cumulative Percentage of Students
1.	33468-	3.06	3.06
2.	33689-	2.48	5.54
3.	12689-	2.45	7.98
4.	33-68-	1.75	9.74
5.	12684-	1.23	10.97
6.	12687-	1.08	12.05
7.	1268--	1.03	13.08
8.	33687-	1.00	14.08
9.	126869	1.00	15.08
10.	12268-	0.96	16.05
11.	126889	0.93	16.97
12.	12-68-	0.91	17.89
13.	33464-	0.89	18.77
14.	334689	0.83	19.6
15.	3346--	0.79	20.4
16.	12686-	0.77	21.16
17.	12688-	0.76	21.92
18.	12068-	0.73	22.66
19.	12468-	0.73	23.39
20.	126-8-	0.67	24.05

a. To more succinctly communicate the science sequences, we have assigned a rank to each of the science courses taken by students in the dataset: 0 = science lab, 1 = life science, 2 = physical science, 3 = general science, 4 = earth or environmental science, 5 = other science course, 6 = biology, 7 = anatomy or physiology, 8 = chemistry, and 9 = physics. A dash (-) means that no science course was taken in the specific grade level.

Source: Analytic transcript data file

²⁰ For instance, the National Mathematics Advisory Panel (2008) concluded that, “although our students encounter difficulties with many aspects of mathematics, many observers of educational policy see algebra as a central concern” (p. xii). Algebra is also widely considered to be a “gateway” to advanced mathematics and science in high school (U.S. Department of Education, 1997).

21 percent. Among the students who repeated algebra 1 in grade 10 (i.e., those who took the course in both grades 9 and 10), the grade-10 algebra 1 CST proficiency rate was 9 percent. These low proficiency rates provide evidence that algebra 1 repeaters are often unsuccessful at mastering the content their second time around.

So while the data do not allow us to conclude that repeating algebra 1 is the wrong intervention for those struggling to learn algebra 1 concepts and skills, they do show that having students repeat the course is not likely to help them reach the level of proficiency for which the state is striving.

Methods for Analyzing Districts' Awareness of, And Response to, Course-taking Patterns

The results of the analysis of the analytic transcript data file provide powerful evidence that school systems struggle to successfully teach — or re-teach — mathematics to students who are not already performing well in math by the time they reach middle-school math, and that this struggle to successfully teach math starts before and continues after the middle grades. The purpose of this study was not simply to describe overall student course-taking patterns in math, which imply something about student performance in math; we also wanted to find out if and how local-level education decision-makers understand and could act upon such information.

To that end, the research team conducted a separate subsample analysis of the analytic transcript data file for each of three unified districts whose leaders had volunteered to engage in conversations with the researchers about the data in their district. For each district, we then provided information on 1) the relationship between students' grade-7 math grades and students' subsequent enrollment in algebra or geometry in grade 9; and 2) the math course-taking patterns for one student cohort, beginning in grade 7 and ending in grade 12 (2004/05 to 2009/10). The intent was to meet directly with district administrators to discuss math and science course patterns, and how district decision-makers might use this information for further internal discussions and action.

In early December 2011, all 24 districts included in the course-taking analysis were notified of an opportunity to

participate in such conversations. The invitation highlighted the opportunity for districts to receive customized results of the initial analysis, as well as to meet with the research team to review and discuss the results. Three districts located in three regions of the state — Northern, Central, and Southern California — opted to participate. These three districts for the most part have low percentages of students performing at Proficient or Advanced on state mathematics and science exams.

To introduce the three districts to the research initiative, we sent a brief overview of the study and a list of questions to be discussed by phone with the research team's primary district contact prior to convening an in-person meeting with members of the research team and district representatives. The initial set of questions covered general background about the district's expectations for mathematics and science course completion by graduation, the district's biggest concerns around mathematics and science course-taking, and the key criteria used for placing students in middle and high school math and science courses. In two of the districts, the primary contact was the district's mathematics coordinator. In the third, the primary contact was the district's middle- and high- school mathematics and science coordinator.

The conversations we had with the district staff varied depending on each district's current reform context. District A had an established research initiative around mathematics and science instruction that drew on the

expertise and resources of both district personnel and local university partners. After learning of this initiative, our research team sought to make our findings relevant to the efforts already in place. For instance, the research team shared the findings at a scheduled meeting of the district and its research partners.

Neither District B nor District C had an established research initiative around mathematics and/or science, but each had one or two district administrators assigned to coordinate mathematics and/or science instruction. In District B, the math and science coordinator made time for a conference call prior to our site visit and reviewed our ranking structure of mathematics courses to give us feedback.²¹ The WestEd research team then conducted an on-site meeting visit to present and discuss the analytic findings.

In District C, the mathematics coordinator was the WestEd research team's main contact. But because the coordinator had only been in the district position for eight months, he did not have deep knowledge about the district's current policies, practices, or history around supporting mathematics instruction. A pre-meeting was not scheduled; an extended in-person visit included the range of questions that were of interest to the researchers

The goals for our on-site meetings with district representatives were three-fold:

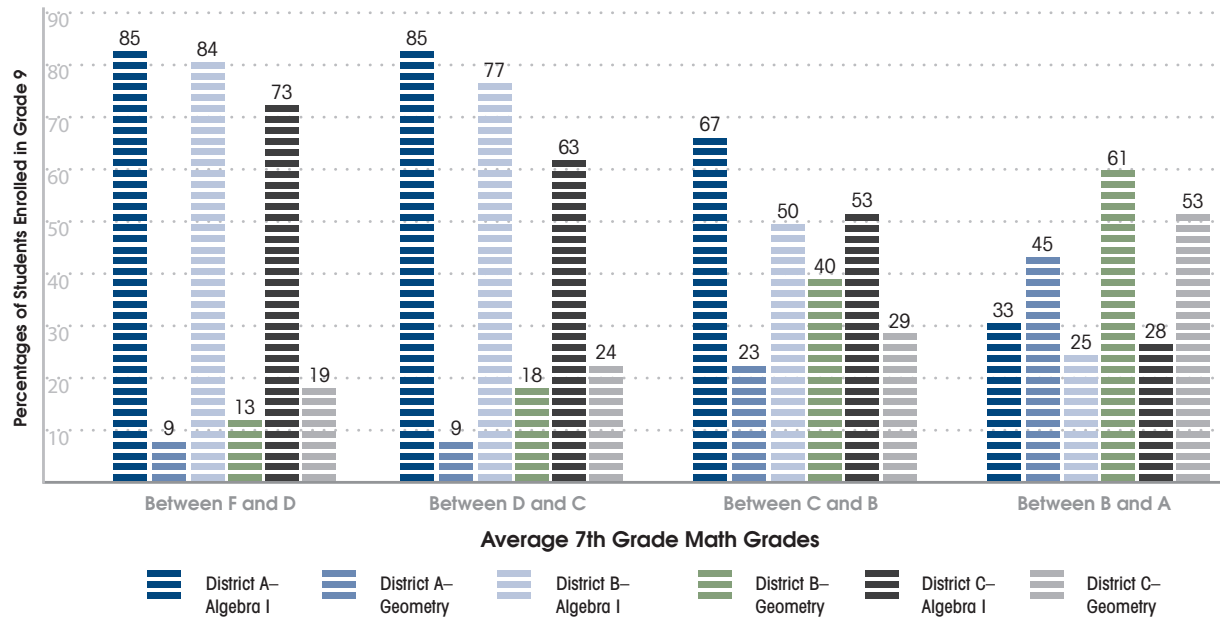
1. To review results from our analysis of the district's data;
2. To learn about current district policies, practices, procedures, and improvement efforts related to mathematics (e.g., course placement criteria, district expectations for mathematics course completion, professional development for teachers); and
3. To discuss how the analysis might contribute to current or future mathematics initiatives in the district.

We were especially interested in the degree to which district administrators were already aware of patterns related to students' achievement and course taking. As detailed later in this section, the districts were already keenly aware of low student performance on state standardized tests in mathematics and had been working to address that low performance. In each of our conversations, district administrators received the results of our analyses with interest, but not with surprise.

Data from each of the three districts, shown in figure 5, provide a snapshot of the patterns that we discussed with the district staff. In general, the results of the analysis for each district were similar to the aggregate analysis of all 24 districts described earlier. For example, as was the case for the entire analytic sample of 24 districts, in the 3 interviewed districts, students who had lower performance in grade-7 math were more likely to be enrolled in algebra 1 in grade 9 compared to students with higher performance in grade-7 math (see figure 5).

21 This district coordinator pointed out that several mathematics course titles in the Cal-PASS analysis no longer exist in the district system because those courses are no longer offered. There was no way for the district math coordinator to verify the appropriate classification for any courses that are not currently in the district's system.

Figure 5. Grade-7 math performance for grade-9 algebra 1 students



Source: Analytic transcript data file

Key Findings

From Conversations With the Districts

Finding 4: Districts are keenly aware of poor student performance in mathematics but less aware of course-taking patterns.

State and federal accountability systems heavily weight student performance on mathematics assessments, and administrators in each district we visited were aware of how their students had been performing in mathematics. In fact, efforts were already underway in each district to boost student math outcomes. Thus, districts were not surprised to see the research team's data showing that many students were not succeeding in mathematics. These districts did not need more evidence to build a case for committing scarce district resources to address poor performance in mathematics; they had already made that commitment, with efforts to boost achievement centered largely on skill building and accurate course placement. Yet prior to receiving the results from our analysis, none of the three districts had examined students' math course-taking patterns to gain more insight into the performance problem. In particular, none had focused on the relationship between students' math performance in early middle school and later course taking and achievement. In part, this lack of focus reflected a disjuncture, or lack of communication, between middle- and high-school staff. Middle-school staff never learned how their students fared in high school; high-school teachers do not systematically seem to know how their students had performed in middle school before transitioning to high school.

Once they themselves tuned into the middle- and high-school mathematics connection, district administrators identified as one possible area for future action a

discussion with their middle-school math faculty aimed at engendering a sense of mission around finding ways to help students become successful in mathematics.

Finding 5: Districts feel great urgency to improve algebra outcomes.

Each district spoke of feeling great pressure to improve mathematics achievement in general and highlighted efforts to address shortcomings. As districts described their efforts to improve student outcomes in mathematics, it became clear that their efforts radiate out from their concern, in particular, about students' performance in algebra. To improve this performance, districts are seeking, for example, to

1. Improve course-placement criteria used to assign middle- and high-school students to the appropriate math courses based on their current mathematical knowledge;
2. Develop middle- and high-school courses designed to meet the needs of students who are not ready for the A-G courses²² (e.g., algebra or geometry).
3. Provide teacher professional development focused on strategies for teaching key algebraic concepts.

These efforts are described in more detail in the following discussion of the individual districts. Here we underscore that, in the face of extreme financial pressures that have resulted, among other things, in districts having fewer staff who now each have more responsibilities, these districts have committed scarce resources to improve algebra results for their students. District staff willing-

²² The A-G courses are those required for eligibility to California's state universities.

to engage in discussions with our team about the analysis shows that improving algebra results is a top priority.

To put these findings in greater context, we next discuss in detail the ways in which each of the districts we visited engaged with the research team about the results of analysis of their data on students' course-taking patterns in math.

District A: Building on an Ongoing Research Collaboration

District A invited the research team to present the findings to its previously established research collaborative, giving us an opportunity to engage with the district and its research partners about the mathematics course-taking patterns of district students. From these meetings, we learned that mathematics course-taking patterns had not previously been investigated in depth and that district data systems were set up in a way that made these types of analyses challenging and time consuming. Research collaborative participants discussed the results of our analyses with interest, creating a list of additional questions about mathematics achievement and pathways that they would like to investigate. Topics for future investigation included the math achievement patterns of English learner students and the math course-taking patterns for grade-8 students enrolled in geometry. Research collaborative participants also developed questions about instructional practices, such as the impact of interventions on student achievement and whether research can help to identify the mathematical skills/conceptual knowledge that students need to master in or by grade 7 in order to successfully complete the math courses required for high school graduation and/or the A-G course requirements for eligibility for California's public four-year higher education systems.

In addition to using analysis results to inform its research agenda, District A sought feedback from the research team on the district's proposed mathematics course-placement decision rules. This feedback and data were incorporated into a district meeting with middle-school principals and lead math teachers later in 2012.

District B: Focusing on Mathematics and the Algebra Challenge

Our research team met with District B's math and science coordinator to present the results and discuss district students' course-taking patterns in math. After our presentation, the district coordinator explained that her district had been talking about mathematics instruction "for years," focused on the question, "What are the implications of students walking out of a mathematics class without the skills they need for the next class?" The coordinator reported that, while this question had been part of an ongoing district conversation for a long time, concern that students were not being well prepared in mathematics had become a more urgent issue in the past year due to district data analysis that revealed decreasing numbers of students performing at a proficient level in algebra. An analysis of the particular students who were not performing at a proficient level suggested the need to revamp the district's course-placement criteria, starting with the grade-7 mathematics placement decision. The coordinator reported that the district's new placement criteria include CST performance and teacher recommendation, but go beyond those factors to also include the results of benchmark assessment of student performance on "key algebraic readiness standards."

The district coordinator reported that the district had also begun to discuss grade-9 mathematics course placements and to revamp the algebra support courses. In past years, grade-9 students whose test results suggested that they

would need additional support in order to succeed in an algebra class were placed in both algebra and an algebra support course. The district's own analysis of student results showed that students enrolled in this course combination were not doing well. The coordinator reported that the support course was not well defined and ended up simply giving students more of what they were already getting in the algebra course itself — a lecture-style course using the same instructional strategies. Beginning in the 2010/11 school year, the district began revising the support course to incorporate more performance-based activities that would give students more practice with the content.

Looking to the future, the district coordinator also mentioned that the district has initiated conversations with local teacher preparation programs to discuss newly credentialed teachers' lack of mathematics pedagogical skills. Participation in a local math network, as well as a state grant focused on mathematics, has given the district a forum in which to share with the local universities its concerns about poor mathematics instruction.

Noting that middle-school teachers tend to be far removed from what ultimately happens to their students, the district coordinator suggested that the results of the analysis could be used to create a sense of ownership in middle schools for students' success in high school. Students rarely go back to their middle schools to visit, she said, and few stories and virtually no data get back to middle school teachers about how their students fare academically in high school.

When asked about next steps in using the results, the coordinator reported that she would take the results to her supervisor, who, in turn, would make a determination about how the district might use them. But by the end of the 2011/12 school year, the supervisor had not been able to make much progress in determining how the data could, or should, be used because the district was going through the hiring process for a new assistant

superintendent who would oversee her department, and no new efforts would be put in place until the assistant superintendent was hired.

District C: The Challenge of Reform with a Culture of School-Site Autonomy

The district mathematics coordinator for District C met with our research team to review the findings. Similar to Districts A and B, District C had already been focused on improving mathematics outcomes for students. For example, the district was creating new courses for students who are not ready to enroll in algebra. The goal of these new courses is to build students' conceptual understanding of mathematics, in contrast to past district efforts to raise math test scores that, according to the coordinator, largely focused on "procedural knowledge and tricks to pass the test." "Most of our kids who are struggling," he said, "are kids for whom procedural mathematics instruction didn't work."

The coordinator reported that the district has been studying the impact of these new courses and has seen some positive outcomes for students; however, variation in how these courses are staffed has resulted in variation in outcomes as well. For example, he reported that in some schools the new algebra courses are staffed by long-term substitutes or new teachers, and the students in their classes are not doing as well as students taking the same classes but being taught by experienced math teachers. The district coordinator has since asked schools to staff the new algebra courses with experienced teachers who have strong classroom management skills. Unfortunately, not all schools have complied with this request. The coordinator lamented that the district culture of school-site autonomy has been a significant barrier to consistent implementation of these new algebra courses across schools.

Reflecting on the results of our analysis, the coordinator felt that the results could be used to bring middle school teachers into the conversation about preparing students for success in algebra. Specifically, he suggested, middle school math teachers who understand the predictive nature of students' success in middle school mathematics might be more motivated to engage in efforts to improve instruction. With the district's receipt of a new grant that focuses on algebra instruction and articulation between the middle and high schools, the coordinator pointed out, the data could complement that new effort.

As in District B, the coordinator for District C reported that his supervisor would need to take the lead on incorporating the results of our analysis into district efforts to improve student math outcomes. At the end of the meeting, the coordinator reported that he would take the results of our study back to his supervisor.

What district conditions are necessary to move from collecting and/or analyzing data to action?

As noted earlier in this section, one of the three districts we visited was able to take our analysis and begin to

incorporate that information into efforts to improve mathematics outcomes for students. Our experience with the other two districts suggests that the district administrators with whom we met did not feel empowered or did not have the authority to make decisions regarding district efforts to improve mathematics. In both examples, these administrators reported that they would need to present this information to more senior district administrators. In one district, that more senior administrator position had yet to be filled, so using the data to inform decisions would have to wait. Beyond working with district administrators who are empowered to make decisions, what other conditions are necessary for a district to move from reviewing data to implementing efforts informed by the data? Identifying those prerequisite conditions will not only help districts build the capacity to use data, but could inform intermediary organizations that seek to support districts in their efforts to improve student outcomes through data analysis strategies.

Considerations For Action.....

One challenge of reporting student outcomes from a large analytic dataset alone is that, oftentimes, researchers know very little about the education inputs underlying the data. In this case, we know the sequence of courses, but little about their content and nothing about the instructional strategies employed in those courses, the students' pre-grade-7 math education, or the rationale by which students were advised to take those courses or to take them at a particular time (e.g., to take algebra 1 in grade 8 versus grade 9).

By contrast, educators and decision-makers in individual districts should have a good grasp of the content, instruction, and elementary mathematics preparation that help to explain the data on student transcripts. Thus, an individual district's replication of the type of analysis employed in this report promises to yield actionable information for the district. We recommend that districts analyze their student course-taking data (including student performance in those courses and on related state tests) to untangle some of the common course sequences that their students are following and use the results to spark and inform conversations about the design of instruction in math and course placement policies.

For districts that choose to conduct such analysis, we point to specific areas for consideration and possible action. Following the district-level considerations, we also provide three state-level considerations.

At the district level:

Math matters in elementary school.

While data availability led us to focus exclusively on middle- and high-school course-taking patterns, the results of our analysis indirectly highlight the critical nature of math education in the elementary grades. Just as students' relative success in higher-level mathematics is closely linked to their success in middle-school math, so too does students' relative success in middle school depend largely on the strength of academic foundations developed in earlier grades.

The large discrepancies in students' grade-7 math performance that were identified in this study suggest that much work must be done in the state's K–6 classrooms to ensure that all students begin middle-school math with a strong foundation. To this end, districts must carefully examine the quality and quantity of professional learning supports they provide to their elementary teachers, particularly in light of ongoing implementation of the Common Core State Standards (CCSS). To effectively teach their students, many more elementary teachers will need to deeply understand math concepts; know which concepts are easiest for students to understand or, conversely, to misunderstand; and recognize how the concepts build on each other over the K–12 continuum.

When students take algebra 1 (that is, in which grade) is less important than whether students are *ready* to take it.

Grade 7 turns out to be a critical year in math that warrants attention. It's in this grade that instruction focuses on pre-algebraic math standards, and it's at the end of this year that many teachers and counselors decide whether or not to move students on to algebra 1 in grade 8. For some students, taking algebra 1 while still in middle school may make the most sense. For others, taking it in grade 9, or even grade 10, may make more sense, presuming the student continues to take math courses and develop the requisite foundation for learning algebra 1 concepts and skills. The analysis presented in this report clearly shows that some students, those with grade-7 CST scores at the level of Proficient or higher, continue to excel in math throughout high school, regardless of when they take algebra 1. On the other hand, it also shows that students who move too quickly through their math sequence in middle school (i.e., taking algebra 1 before they are fully prepared) *never* reach the level of Proficient on the algebra 1 CST, an outcome that has direct consequences for their performance in higher-level high-school math courses and, ultimately, for their placement in postsecondary math courses should they go on to higher education.

Thus, district emphasis should not be on accelerating all students into grade-8 algebra 1, but, instead, should be on ensuring that students are ready for the next level of math, all along the way. In short, the process by which school districts assess students' understanding of math and make placement decisions (or advise students and their families on placement options) is key. The decision about when a student takes algebra 1

should be based on a careful review of the student's record to date in mastering pre-algebraic concepts, measured in several ways: prior-year CST scores, teacher recommendations, results from district-administered benchmark assessments, and consultation with parents, counselors, and students themselves. Diagnostic tests that look at a student's performance in particular strands of pre-algebraic work may also provide useful information when advising students.

We recognize that, practically speaking, this placement approach leads to differentiated math pathways in the secondary grades. In the short run, it may look as if those students who wait to take algebra 1 in grade 9 or 10 are somehow being left behind. But study results suggest that if students have the necessary math foundation when they first take algebra 1, whenever that is, they have a much better chance of becoming proficient in algebra 1 content. In turn, algebra 1 proficiency serves as the necessary foundation for being successful in the next higher level of math after algebra 1. Thus, in thinking about when students take algebra 1, districts must take the long view, with long-term outcomes (e.g., students ultimately attaining proficiency in algebra 2 or a higher-level math course) becoming the marker for success in high school. Our analysis clearly shows that students who are not ready for higher-level math, but are moved forward anyway, do not end up completing algebra 2 at the level of Proficient or higher by the time they finish high school.

Having students repeat algebra 1 is generally not an effective strategy for supporting students who struggle in their first attempt at algebra.

In the absence of more-customized interventions, teachers and counselors often recommend that

students who have taken algebra 1 but are not ready for the next higher level of math simply give first-year algebra another try. Yet, our study shows that few students who repeat algebra 1 ever reach the level of Proficient or higher on the algebra 1 CST. This finding underscores the importance of the prior consideration — that students not be moved to the next higher math course until they have demonstrated strong foundational skills in their current course.

In grappling with the implications of this consideration, we focus on two distinct groups of students: grade-8 students with a weak math foundation who are currently enrolled in algebra 1 for the first time; and grade-7 students with a weak foundation who are currently enrolled in a pre-algebra course, with a yet unknown placement for the following year.

Many in the first group will reach the end of their current course without being able to attain the level of Proficient on their algebra 1 CST. So, given the study finding that repeating algebra 1 rarely results in student proficiency, what is the appropriate grade-9 placement for these learners? Here, it helps to consider the difference between having a student *repeat* a course (with the exact same content and the same instructional strategies, if not the same teacher) and having a student *re-take the same general content but have it taught in a different way*. For example, to more effectively re-teach these students and help them build a strong foundation when tackling algebra 1 concepts again in grade 9, a school might bring to bear a tailored set of instructional approaches that focus on conceptual areas in which students have demonstrated need, as identified by benchmark assessments and diagnostic tests, as well as teacher recommendations. A grade-9 math program for such students might include, for example, having them spend extended time focused on particular content areas; work with a tutor or use other support

structures; and/or work with a different math teacher who employs different instructional approaches and is guided by data about students' existing algebraic strengths and weaknesses. Having students take geometry at the same time they revisit algebra is another option worth considering for students who are particularly interested in math or are concerned about the stigma of not moving forward in their math sequence. While there are no ready answers for how best to meet the needs of these students, we caution, again, that repeating the current algebra 1 course is unlikely to move many of them to the proficient level.

For the second group of students — grade-7 students with a weak foundation who are currently enrolled in a pre-algebra course — we suggest similar approaches that fall broadly into the category of “pre-algebra support” that may be made available to students in grade 7 and grade 8. Our conversations with three school districts suggest that pre-algebra support classes and extended learning blocks, as well as two-year course designs, may be approaches worth assessing to strengthen foundations during grade 7 and grade 8, before having students take algebra 1 in grade 9. What we do not suggest is either moving students forward to algebra 1 when they have not yet reached the proficient level in pre-algebra, or simply having them repeat a pre-algebra course.

With regard to both groups, we suggest a careful review of district and school-level course-placement policies, and a simultaneous examination of students' particular learning needs as a way of providing more targeted instructional approaches than can be provided with any course that a student is asked to retake. And, while we fully realize that specific instructional approaches are beyond the scope of this report, there is a broad base of research on effective instructional techniques for teaching math that should

be considered when developing alternatives to students simply repeating courses (see for example, Siegler et al., 2010; Gersten et al., 2009).

Irrespective of students' math performance, taking four years of high-school math strengthens their postsecondary opportunities.

Students should continue to be encouraged to take four years of math in high school, a path considered to be a strong bridge to postsecondary education in general. The A-G high-school course sequence established as an eligibility requirement for California's two public university systems includes three math courses (typically algebra 1, geometry, and algebra 2), and a fourth math course is strongly recommended.

Yet our analysis shows that just over 30 percent of students in our sample did not take math during their senior year in high school. Even among those who were strong math students in grade 7, 25 percent did not take a fourth math course in high school. For students who have had challenges in math in middle and high school, not taking math in senior year has the potential to make the journey to college that much more difficult. A typical community college math-placement process for entering students includes administration of an algebra proficiency test. For students who do not study math as a high-school senior (as well as for others who may not move directly from high school to college), having to take the college placement test after not having done any math for at least a year can be a major deterrent to placing into a college-level math course. As we noted earlier, students who do not do well on their placement test are likely to end up in a developmental, or remediation, math course, which yields no college credit.

Seen from the angle of A-G completion, we are concerned that the proportion of students not taking four years of math in high school is an unintended consequence of guiding some middle-school students into algebra 1 before they are sufficiently prepared. Our analysis shows that 44 percent of students in the sample passed algebra 2 with sufficient grades to meet minimal eligibility standards for California's two public university systems, but only 29 percent reached proficiency on the CST. Students who spend more time in middle school (and before) developing a strong base in pre-algebra might be more likely to succeed in a four-year math sequence in high school, beginning with algebra 1 in grade 9, and to also demonstrate proficiency on the CST.

Current course sequences are typically not cost effective.

One of our greatest concerns from the data analyzed in this study is that students who initially struggle in algebra 1 infrequently reach the level of Proficient or higher on the related CST, even after retaking the course and test multiple times. For example, 32 percent of students reached proficiency in algebra 1 at grade 9, and that number increased by just two percentage points over the next two years (to 34 percent). A similar pattern can be seen in our data around algebra 2. The sad fact is that thousands of students take CSTs multiple times during high school and do not succeed in demonstrating proficiency.

This pattern of repeating without succeeding has direct implications for how resources are being used, and how they might be allocated differently. School districts should review the design of courses and course sequences with cost considerations in mind — costs related to time, teacher allocation, and student

placement — to assess whether their systems are operating as cost effectively as possible.

The analysis of course-taking patterns can be used to support the development of district-level policies around course placement. Beyond district policy development, these data can also answer questions of interest to teachers, broadly speaking. For example, “How did the students I taught three years ago in grade 7 end up doing in high school math?” can be answered with an analysis of transcript data at the school-site, or even the classroom, level. The potential to use this simple form of feedback as a way of engaging educators on reviews of instructional strategies seems great.

At the state policy level, the following additional considerations are warranted.

State-level policy incentives that encourage districts to have students complete algebra 1 in grade 8 should be revisited.

California State Board of Education policy currently encourages districts to have students, broadly, complete algebra 1 before they start high school; this is incentivized through a penalty schools receive for having grade-8 students take the general math CST instead of the algebra 1 CST. Regardless of how those students perform on the general math CST, their school’s Academic Performance Index (API) score will reflect a full performance level lower for each test taker. For example, when a grade-8 student performs at the Proficient level in general math, for purposes of the school’s API score, the student’s performance will be calculated at the Basic level. This policy was not originally intended to compel districts to place students in courses for which the students are not yet ready, but, practically speaking, it has done just that.

This policy should be carefully reviewed as the state moves to implement changes in its accountability system pursuant to the recently enacted California Senate Bill 1458 (California State Legislature, 2012b) and as federal accountability systems evolve pursuant to anticipated changes in the Elementary and Secondary Education Act.

The Common Core State Standards can enable substantial revisions in instructional approaches in math.

Implementation of the CCSS, with their emphasis on deeper learning in math, provides a new opening for discussions of math instruction, course pacing, and course placement. The CCSS provide occasion to look carefully at the ways in which districts and schools can strengthen support for students’ progress through a course of study in mathematics that will prepare them for higher education eligibility and success in postsecondary education and careers. State policy can reinforce district initiatives that support teachers, provide for updated instructional materials, and support innovations in instructional methods. The State Board of Education has been expressly authorized to examine the math CCSS as a result of recently enacted California Senate Bill 1200 (California State Legislature, 2012a), which is intended to provide greater clarity about expectations for math sequences in the middle grades.

Strengthening the supply of qualified math teachers in California is essential.

The findings of this report point to the essential fact that, when it comes to learning math, the quality of instruction matters. With significant numbers of students in California ill equipped to move forward in

math, guaranteeing strong instruction from elementary school to high school is paramount. How the state supports the pipeline for math teachers — preparing them, recruiting and supporting new teachers, and continuing to support and develop veteran teachers in their work — is critical. Ensuring the quality of teachers we need will require significant professional learning supports for teachers at all levels, particularly teachers with multiple-subject credentials who do not have a background in mathematics. Teacher credentialing programs should also examine how well their teacher credential candidates are prepared to provide

the effective instruction needed to generate the deeper learning required by the CCSS. The California Commission on Teacher Credentialing (2012) has convened the Teacher Preparation Advisory Panel, its charge being to “review the content, structure and requirements for California teacher preparation and licensure to ensure that these remain responsive to the conditions of teaching and learning in California’s public schools” (p. 1). This provides a timely opportunity to examine preparation for teaching math, in terms of both content and pedagogy, as the state implements the CCSS.

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Appendix

Data Source

In the spring of 2011 we made arrangements to access a longitudinal student-level dataset maintained by the California Partnership for Achieving Student Success (Cal-PASS). Cal-PASS is an initiative that collects, analyzes, and shares student data.²³ Over 8,000 K–12 schools participate in the partnership.

Analysts within Cal-PASS identified 24 unified school districts that had uploaded data to its data repository in each of the school years from 2004/05 through 2009/10. These districts had each uploaded a student demographics file, a coursework file, and a California Standards Test (CST) score file in each of the years from 2004/05 through 2009/10. While Cal-PASS has data-sharing agreements with more than 24 unified districts, not all of these districts had complete data files that could be analyzed. In some instances the data upload was incomplete, such as when not all of the demographics/coursework/CST files were uploaded to Cal-PASS. In other instances a district may have skipped a year uploading files. And finally, at the time of the initial scan of potential districts to be included in this study, some unified districts had not yet uploaded their 2009/10 data.

The analysis was restricted to unified districts to enable students to be observed in both middle school and high school. From these 24 unified districts, students who

were not observed within the same school district for six years from 2004/05 through 2009/10 were filtered out. If the sample had included students who transferred into or out of districts at some point in the six years, it would be impossible to ascertain the math course enrollment of those students when they were not enrolled in the district. This would be a missing-data issue for the analysis. However, by only including students who were observed for six consecutive years in the same district, this analysis is only representative of the stable student population. In conversations with some of the districts involved in the study, district staff thought it was reasonable to restrict the sample to stable students in order to have a complete data structure to analyze. This led to a final sample of 24,279 students across the 24 districts.²⁴

From the student demographics, coursework, and CST score files a range of variables were collected. The demographics file contained ethnicity, gender, free- or reduced-price lunch status, English language learner status, special education status, date of birth, and parent education level. The coursework file contained the following relevant variables: course name, California Basic Educational Data System (CBEDS) code, grade earned, semester, school year, and grade level. The CST file contained the name of the test taken, the scale score received, the performance level, and the year taken.

²³ More information can be found at the Cal-PASS website: <http://www.calpass.org/default.aspx>

²⁴ Because not all students took the math CST in each school year from 2004/05 through 2009/10, the analysis of students' CST data is a subset of the final analytic sample.



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